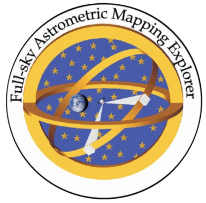


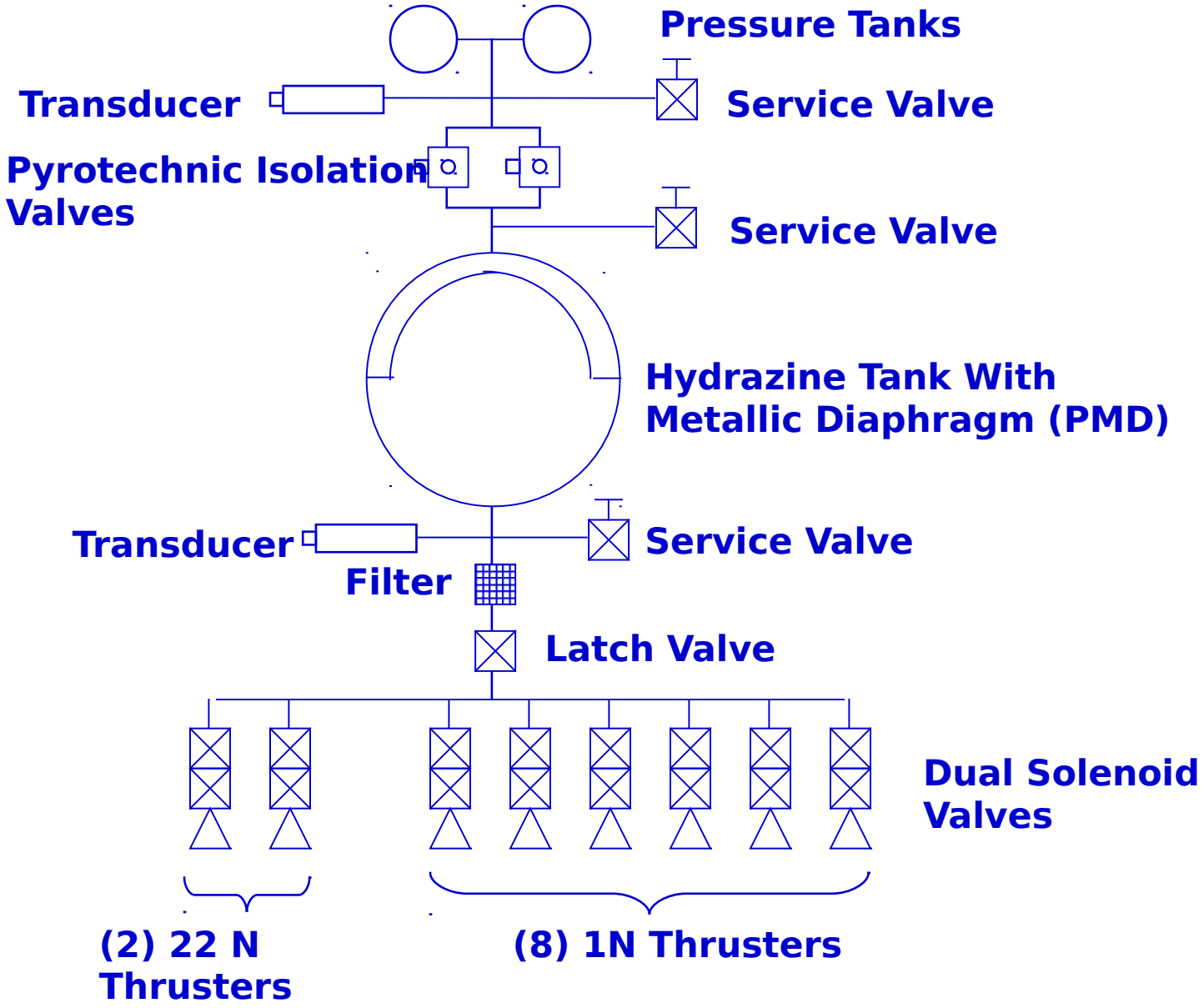
Propulsion Update

FAME Technical Interchange Meeting (TIM)

September 19-20, 2001

Mike Osborn
Naval Research Laboratory
202-767-9168
mosborn@space.nrl.navy.mil

FAME Propulsion Schematic



Current Propulsion Baseline

- 8 Total Hydrazine Thrusters
  - Two 22N Thrusters (Active Nutation Control, Delta V)
  - Six 1N Thrusters (3-Axis Control, Slew, and Spin)
  - Refurbish In-House Existing Thrusters
- Accept Single Off-the-Shelf Tank Design Due to Schedule Limitations
  - Options are Not Optimal - Too Big, Too Small, or Elastomeric Diaphragm
  - Small Tanks Require Augmented Pressurization Systems
  - Pressurization Trade Between Active Control and Blowdown
  - Blowdown Pressurization Tanks Have Large Volume and Mass
    - Tank Size and Mass Are Not Optimal Due to Availability
    - Layout of Packaging Options is In-Work
- ICM Flight Spare Latch Valve
- In-House Fill Valve, Pyrotechnic Isolation Valve
- Use STAR 30BP Apogee Kick Motor (AKM)
  - Originally Built for Hughes 376 GEO Communications Satellites
- Rent or Borrow AKM Shipping and Handling Equipment
  - Investigate Modification of STAR 37FM Equipment (CLEMENTINE)

Propellant Budget (Not Worst Case)

Event	Event Description	Delta V (m/s)	Ave Isp (sec)	Initial Pressure (psia)	Ave Thrust (N)	Initial Mass (kg)	Delta V Prop (kg)	ACS Prop (kg)	Prop Remaining (kg)	Burn Time (sec)
0									49.9	
1	Null Delta 3rd Stage Tip Off		160	350.0	5.09	1133.4		0.13	49.8	40
2	Inertial Pointing (3-axis limit cycle)		160	330.1	4.89	1133.3		0.04	49.7	13
3	Slew Manuevers		160	324.1	4.68	1133.2		0.17	49.5	58
4	Safe Hold Mode Spin up/down		160	301.7	8.92	1133.0		0.06	49.5	11
5	Spin-up FAME with SRM		220	294.3	7.27	1133.0		1.38	48.1	408
6	Active Nutation Control		160	191.5	2.02	1131.6		5.68	42.4	4412
7	Spin Axis Precession (6 degrees)		160	78.4	1.16	1125.9		0.16	42.3	218
8	STAR 30BP Firing		290	77.1	38030	1125.8			42.3	53
9	Active Nutation Control		160	77.1	1.09	687.8		1.20	41.1	1726
10	Despin FAME with Spent STAR 30BP		220	68.7	1.94	686.6		1.37	39.7	1519
11	Slew Manuevers		160	61.1	0.89	685.2		0.71	39.0	1245
12	Inertial Pointing (3-axis limit cycle)		160	57.8	0.82	684.5		1.58	37.4	3026
13	Hydrazine to Make-up Star 48 TI Error (.5%)		220	51.5	13.63	682.9	12.85	0.35	24.2	55
14	Hydrazine to Make-up Star 48 Pointing Alt Error		220	27.1	9.32	669.7	0.42	0.01	23.8	3
15	Hydrazine to Make-up Star 30BP TI Error (.5%)		220	26.7	8.81	669.3	2.92	0.08	20.8	19
16	Hydrazine to Make-up Star 30BP Pointing Error		220	24.1	8.35	666.3	0.05	0.00	20.7	0.4
17	Jetison STAR 30BP and Adaptor	0.5	220	24.1	8.33	666.2	0.15	0.00	20.6	1.1
18	Slew Manuevers		160	24.0	0.36	586.0		0.02	20.5	81
19	Inertial Pointing (3-axis limit cycle)		160	23.9	0.36	586.0		0.05	20.5	232
20	Decrease Perigee to Final GEO Orbit	5.44	220	23.9	8.09	585.9	1.48	0.10	18.9	28
21	Decrease Apogee to Final GEO Orbit	5.44	220	22.8	7.71	584.3	1.47	0.10	17.3	29
22	Slew Manuevers		160	21.7	0.32	582.8		0.28	17.1	1346
23	Inertial Pointing (3-axis limit cycle)		160	21.6	0.32	582.5		0.79	16.3	3899
24	Safe Hold Mode spin up/down		160	21.1	0.62	581.7		0.71	15.6	1776
25	Raise Apogee to Disposal Orbit	5.44	220	20.7	7.02	581.0	1.47	0.10	14.0	32
26	Raise perigee to Disposal Orbit	5.44	220	19.8	6.74	579.4	1.46	0.10	12.4	33
28	5% Unusable Residual		160	19.0	0.55	577.9	2.49		9.9	7077
29	Fuel Margin		160	17.9	5.62	575.4	9.94		0.0	2774

49.9 Kg (110 lb) Propellant Load ~ 20% Margin

Tank Selection

- Tank Selection Issues Requires Additional Analysis
  - Requires Quantification of Propellant and Pressurization
  - Single Blowdown Tank vs. Augmented Pressurization Tank
  - Mounting Options Include Boss and Girth (Tabs or Skirt)
- PMD Selection Limits Availability
  - Passive PMD Is Not Possible (Accelerations, Spin, and CG Control)
  - Elastomeric Tank Bladder Not Baselined Due to CG Uncertainty
  - Single Use Metal Diaphragm Characteristics
    - Higher ΔP From Gas to Liquid
    - Better Cg Control (Gross Mass Motion Slosh)
- Cost and Delivery Schedule Require a Qualified Heritage Design
  - New Design and Qualification Not Possible (24 Month Delivery and Costly)
    - Program Schedule Supports “Off-the-Shelf” Tank Procurement
    - Multiple Designs Available from Atlantic Research and Arde
- “Off-the-Shelf” Pressure Tank Procurement Also Required for Baseline

Small Metal Diaphragm Tank (Baseline) (1 of 2)

- **Atlantic Research Corporation (ARC) P/N AO882300**
  - **19 x 21 Inch Elongated Sphere (3125 Cubic In)**
- **Maximum Expected Operating Pressure (MEOP) 300 psia**
- **Proof 450 psia, Minimum Burst 650 psia**

  Polar Inlet and Outlet Tubes
  - **Tank Weight 7.62 kg (16.8 lb)**
  - **Polar Boss Mounted**
  - **AL 2219 Shell, AL 1100 Metal Diaphragm**
- **Developed for NRL CLEMENTINE Program**
- **Requires Secondary Pressurization System**
  - **Fill tank to 97% with Hydrazine**
  - **110 lb Hydrazine Maximum Capacity**

Small Metal Diaphragm Tank (Option) (2 of 2)

- **ARDE P/N 4687**
  - **19 x 20 Inch Near Sphere (3182 Cubic In, Liquid Volume)**
- **Maximum Expected Operating Pressure (MEOP) 400 psig**
- **Proof 450 psia, Minimum Burst 600 psia**
  - **Qual Burst 1196 (by Similarity)**

  Polar Inlet and Outlet Tubes

  Bolted Flange and Slip Boss Mounting
  - **Tank Weight 8.3 kg (18.3 lb)**
  - **Cryo-Formed 301 Shell, 304 Ring Stabilized Metal Diaphragm**
- **Developed for NRL Sandia ODES Program**
  - **Recently Qualified for ORBCOMM IV**
- **Requires Secondary Pressurization System**
  - **Fill tank to 97% with Hydrazine**
  - **112 lb Hydrazine Maximum Capacity**

Big Metal Diaphragm Tank (Option)

- Atlantic Research Corporation (ARC) P/N AO882300
  - 31 inch Near Sphere (16,615 Cubic In)
- Maximum Expected Operating Pressure (MEOP) 318 psia
- Proof 472.5 psia, Minimum Burst 567 psia

  Polar Inlet and Outlet Tubes
  - Tank Weight 27.2 kg (60 lb)
  - Polar Boss Mounted with Threaded Receiver
  - AL 2219 Shell, AL 1100 Metal Diaphragm
- Currently Under Development for Boeing
- Large Size Accommodates Blowdown Pressurization
- Large Tank is Difficult to Package in the Current Design

Schedule Milestones

- Propellant Tank Contract 1/1/02- 12/02
- Pressure Tank Contract 1/1/02 - 12/02
- Pressure Transducer Procurement 3/02-10/02
- Propellant Filter Procurement 3/02-10/02
- Thruster Refurbishment 5/02- 9/02
- Offline Sub-Assembly Fabrication 11/02 to 2/03
- Propulsion to Bus Integration 6/03 - 7/03
- Propulsion Functional Testing 7/03 - 8/03
- Integration Propulsion Test (Flight Electronics) 11/03 - 12/03
- Test Readiness Review 1/04
- Flight Environmental Testing and Vehicle Check Out 1/04 - 3/04
- SRM Contract 4/02 - 4/04 (Deliver to Cape)
- SRM to Interstage I&T 4/04
- Propulsion Range Support 4/04 - 10/04
- Launch 10/04